

# Hospital Nurses' Occupational Exposure to Blood: Prospective, Retrospective, and Institutional Reports

## ABSTRACT

**Objectives.** This study examined nurses' risk of exposure to blood resulting from injuries with needles and sharps, the methods of estimating those risks, and the factors affecting risks.

**Methods.** Nurses on 40 medical units in 20 hospitals in cities with a high incidence of AIDS were studied. Percutaneous injuries were documented for every shift during a 30-day period. These prospective reports were compared with retrospective and institutional reports. Factors affecting the likelihood of injuries were also explored.

**Results.** Based on the prospective reports, the rate of injuries to staff nurses was 0.8 per nurse-year. Prospective and retrospective rates were similar, while institutional rates were significantly lower. Factors associated with increased injuries included recapping needles and temporary work assignments. Working in hospitals characterized by professional nurse practice models and taking precautions to avoid blood contact were associated with fewer injuries.

**Conclusions.** Injuries from needlesticks are more common than institutional reports suggest and do not occur at random. Diminishing the frequency with which nurses recap needles, increasing precautions they take, reducing use of temporary nursing personnel, and implementing organizational changes may lower the odds of nurses being injured. (*Am J Public Health.* 1997;87:103-107)

Linda H. Aiken, PhD, Douglas M. Sloane, PhD, and Jennifer L. Klocinski, MA

## Introduction

The possibility of acquiring the human immunodeficiency virus (HIV) from patients concerns health care workers and potentially threatens their participation in the care of patients with acquired immunodeficiency syndrome (AIDS).<sup>1-5</sup> Through December 1995, 49 confirmed cases and 102 suspected cases of occupationally acquired HIV infection in the United States had been documented; nurses account for the largest number of cases.<sup>6</sup> At least 20 different pathogens have been transmitted by needlestick injuries,<sup>7,8</sup> including hepatitis B, which accounted for 1000 cases of health care worker infection in 1994.<sup>9</sup> While the risk of occupational transmission of HIV is low per exposure<sup>10,11</sup> (0.3% vs 30% for hepatitis B<sup>12</sup>), terminal illness in the source patient substantially increases the odds of HIV infection in the injured health care worker,<sup>13</sup> a finding that underscores the importance of obtaining accurate estimates of inpatient AIDS care nurses' rates of exposure to blood and understanding factors associated with their exposure rates.

## Methods

Our data derive from a multiobjective study of hospital AIDS care involving 40 inpatient units in 20 hospitals in 11 cities with a high incidence of AIDS. The study was designed to determine how the organization of inpatient hospital care is related to nurse and patient outcomes.<sup>14,15</sup> Two organizationally distinct unit types and two hospital types were studied—dedicated AIDS units vs AIDS care on multidisciplinary medical units, and “magnet” hospitals vs conventionally organized hospitals. Magnet hospitals, also known as professional nurse practice

models, have distinct organizational attributes such as decentralized decision-making, policies promoting nurse autonomy and control, and work organization emphasizing continuity of care.<sup>16,17</sup>

The part of this larger study we report on here pertains to a particular nurse outcome—nurses' occupational exposure to blood—and has the following features: (1) It provides epidemiological coverage with numerator, denominator, and time frame all specified in order to compute exposure rates. (2) It uses prospectively gathered reports of exposures by shift, involving recall over only 8 to 12 hours, as well as retrospective (questionnaire) and institutional reports. (3) It employs a standard protocol across 20 hospitals, allowing for the observation of a comparatively rare event in a large sample. (4) It provides for confidentiality, thus avoiding one of the biases in the reporting of exposures in existing hospital reporting systems. (5) It includes information that enables us to determine whether certain characteristics of nurses, nursing practices, and hospital organization affect the likelihood of nurses' sustaining a percutaneous injury.

The authors are with the Center for Health Services and Policy Research, University of Pennsylvania, Philadelphia. In addition, Linda H. Aiken is with the Department of Sociology and the Population Studies Center; Douglas M. Sloane is with the Population Studies Center; and Jennifer L. Klocinski is with the Department of Sociology, all at the University of Pennsylvania. Douglas M. Sloane is also with the Department of Sociology and the Life Cycle Institute, The Catholic University of America, Washington, DC.

Requests for reprints should be sent to Linda H. Aiken, PhD, Center for Health Services and Policy Research, University of Pennsylvania, 420 Guardian Dr, Philadelphia, PA 19104-6096.

This paper was accepted June 28, 1996.

### *The Prospectively Gathered Data*

Information on exposures to blood was derived from coupons filled out by all staff and temporary nonstaff nurses on the study units at the end of each shift over 2 periods of 1 month each in late 1990 and early 1991. Nurses indicated on the coupons whether they had incurred a needle or sharp injury (hereafter referred to as needlestick injury or simply injury) during their shift; an injury was defined in the coupon booklet nurses received as "a puncture with a needle or sharp instrument that is contaminated with blood." A total of 14 379 shifts were worked by participants in this part of the study, and the 12 349 coupons returned represent an 86% response rate, high enough to make bias unlikely. Data were analyzed from 12 075 (98%) of the returned coupons—11 039 were completed by 920 staff nurses and 1036 were completed by an unknown number of nonstaff nurses temporarily assigned to a study unit.

### *The Retrospectively Gathered Data*

Two months before the prospective data collection, 865 of the 920 staff nurses who participated in the prospective part of the study received questionnaires that asked, among other questions, "Have you ever been stuck with a needle or sharp object contaminated with blood?" Nurses who responded affirmatively were asked (1) "How many times has this occurred?" (2) "How many of these incidents occurred in the past month?" and (3) "Did this incident go unreported to your institution's office of employee health or comparable office?" The number of hours per week each nurse worked was provided by head nurses.

Of the 865 prospective study nurses who received the retrospective questionnaires, 762 (88%) returned them. After eliminating questionnaires with missing data, we were able to use 732 (96%) of the completed questionnaires and to link (using common identification numbers) retrospective injury reports to prospective injury reports for 732 (80%) of the 920 staff nurses in the prospective part of the study.

### *Institutional Reports*

Each hospital was asked to provide dates of reported injuries, which study unit the injury occurred on, the circumstances surrounding the exposure, the cause of the injury, the action taken after the nurse reported the injury, and the nurse's educational background. The re-

porting period extended from the month before the retrospective questionnaire was given to the nurses to the end of the prospective data collection. Data were obtained from 15 of the 20 hospitals.

### *Statistical Analysis*

From the prospective data, we calculated hourly and annual needlestick injury rates for staff nurses and temporary nonstaff nurses. We derived binomial exact 95% confidence interval estimates for the annual injury rates for both groups and calculated incidence rate ratios to describe the difference between them. The significance of the difference between groups was tested by means of "mid-point" two-tailed exact significance tests, following Rothman.<sup>18</sup>

We analyzed differences between the prospectively and retrospectively reported injury rates for staff nurses by the same procedures described above. Because the prospective and retrospective injury reports came from the same sample of nurses, we undertook additional analyses to determine (1) whether the prospective reports of injuries were independent of the retrospective reports (i.e., whether they involved different nurses) and (2) whether the overall distributions of prospective and retrospective-report injuries were alike. The first objective was accomplished by constructing a  $3 \times 3$  contingency table in which the number of injuries reported prospectively was cross-classified by the number of injuries reported retrospectively and determining, by means of a likelihood-ratio chi-square statistic, how well that table was described by a model of independence. The second objective was accomplished by testing, with the same statistic, the fit of a model that posited that the marginals of the  $3 \times 3$  table were homogeneous—that is, that the numbers of nurses who prospectively reported none, one, and two or more injuries equaled the numbers of nurses who retrospectively reported none, one, and two or more injuries.

Our comparison of the retrospective and prospective data with the institutional data on needlestick injuries was less rigorous. The institutional data did not include estimates of the number of nurses who were working or the number of hours that they worked during the period that the institutional data covered. We calculated and compared the average number of injuries per month that were reported in the three different data sets for the nursing units in the 15 hospitals that provided data of all three types. While this analysis was

unable to control for hours at risk of injury, the three data sets contained essentially the same individuals and permitted a rough comparison.

Finally, we used logistic regression techniques to determine whether there were certain characteristics of nurses or their work-related practices or environments that were related to their likelihood of being injured, controlling for the duration of risk of being injured.

## **Results**

The first two columns of Table 1 show the number of shifts reported on by the 920 staff nurses and the unknown number of nonstaff nurses in the prospective part of the study; the number of hours they worked; the total number of needlestick injuries that were reported; and the number of staff nurses who were injured. Dividing number of injuries by total nurse-hours yields an estimate of the injury rate per nurse-hour, and this rate multiplied by 1800 yields the injury rate per nurse-year.

The annual injury rates for staff and nonstaff nurses were 0.84 and 1.38, respectively. The incidence rate ratio shown at the bottom of the table indicates that the injury rate for nonstaff nurses was 1.65 times as large as the injury rate for staff nurses. Although this difference is not statistically significant, it seems sizable enough to warrant further attention with a larger sample of nonstaff nurses.

The last two columns of Table 1 show, for the 732 staff nurses who contributed both prospective and retrospective data, that the difference between the prospectively reported injury rate (0.77 injuries per nurse-year) and the retrospectively reported injury rate (0.61 injuries per nurse-year) is small and nonsignificant (incidence rate ratio = 1.26,  $P = .33$ ).

Our test of the significance of the difference between the prospectively and retrospectively reported injury rates may be inappropriate, since it assumes that the rates compared were derived from two independent samples. It therefore was necessary to find an alternative way to discern whether the prospective and retrospective reporting of injuries were alike in the sense that they yielded similar reports, or whether they only appeared to be alike in this case because it was the same group of nurses doing the reporting in each data set.

Evidence that the former and not the latter is the case is found in Table 2, where the number of injuries that were prospec-

tively reported by the 732 nurses is cross-classified by the number of injuries that they reported retrospectively. Both the likelihood-ratio chi-square ( $L^2$ ) test and Fisher's exact probability associated with the model of independence confirm that the prospective injury reports are independent of the retrospective injury reports. It was not the same subgroup of nurses, with some underlying proclivity to sustain needlestick injuries, who were reporting these injuries both prospectively and retrospectively and yielding similar rates. At the same time, the small value of  $L^2$  and the high probability associated with the model of marginal homogeneity—which hypothesizes that the distributions of prospectively and retrospectively reported injuries are identical—indicate that there is no statistical reason to believe that the two rates are not the same, in spite of the fact that different nurses were responsible for them.

The monthly rate derived from the institutional data is considerably lower than those derived from either the retrospective or the prospective data. A total of 41 injuries were reported on the study units of the 15 hospitals that provided institutional injury data over the 6-month study period, which implies a monthly injury rate of 0.46 per hospital. In our prospective data, by comparison, 24 injuries were reported by nurses from these 15 hospitals over the course of 1 month, which yields a monthly rate of 1.60 injuries per hospital. The nurses from these 15 hospitals who responded to the retrospective questionnaire reported 29 injuries over the preceding month, for a monthly rate of 1.93 injuries per hospital. Clearly, the institutional reports reflect only a fraction of the actual injuries that occur. The institutional data we have are quite imprecise, however, and work needs to be done to determine precisely what that fraction is.

In our final analyses, we returned to the data from all 20 hospitals and used logistic regression models to determine whether certain characteristics of nurses, or of the hospitals or units in which they worked, were related to the likelihood of an injury's occurring (1) during the 1-month period of the prospective data collection, (2) during the 1-month period preceding the completion of the retrospective questionnaire, and (3) at any time during the careers of these staff nurses. The latter variable was determined from a retrospective questionnaire item that asked nurses whether they had "ever been stuck with a needle or sharp object contami-

**TABLE 1—Needlestick Injuries, Hours at Risk, and Incidence Rates among Nurses in 20 Hospitals in 11 Cities, 1990 through 1991**

	Prospective Data		Staff Nurses	
	Staff Nurses	Nonstaff Nurses	Prospective Data	Retrospective Data
No. nurses	920	...	732	732
No. shifts	11 039	1036	9 076	...
Total nurse hours	103 017	9112	84 421	109 192
Hours per shift	9.3	8.8	9.3	...
Total injuries	48	7	36	37
Nurses injured	44	...	33	32
Injury rate/nurse-hour	0.000466	0.000768	0.000426	0.000339
Injury rate/nurse-year	0.84	1.38	0.77	0.610
95% CI	0.62, 1.11	0.56, 2.85	0.54, 1.06	0.43, .84
IRR	1.65		1.26	
95% CI	0.63, 3.67		0.77, 2.05	
Two-tailed exact <i>P</i> associated with $H_0$ : IRR = 1	.23		.33	

*Note.* Numbers in the first two columns pertain to the full sample of staff nurses and an unknown number of nonstaff nurses from whom prospective (shift coupon) data were collected. Numbers in the last two columns pertain to the matched sample of staff nurses from whom both prospective and retrospective (questionnaire) data were collected. Retrospective data were not collected from nonstaff nurses. The number of shifts worked by staff nurses during the retrospective reporting period is unknown. CI = confidence interval; IRR = incidence rate ratio.

**TABLE 2—Two-Way Cross-Classification of Prospectively and Retrospectively Reported Injuries among Staff Nurses in 20 Hospitals in 11 Cities, 1990 through 1991**

Injuries Prospectively Reported	Injuries Retrospectively Reported			Total
	0	1	2 or 3	
0	669	27	3	699
1	28	1	1	30
2 or 3	3	0	0	3
Total	700	28	4	732

$L^2$  (independence) = 2.41, 4 df,  $P$  = .661

Fisher's exact  $P$  = .279

$L^2$  (marginal homogeneity) = 1.14, 3 df,  $P$  = .768

*Note.* A small constant (.05) was added to each observed frequency in the table before expected frequencies and likelihood ratio chi-square values for the two models were calculated.

nated with blood." It was included to supplement the information from items 1 and 2 above, which involve a much smaller number of injuries over a shorter period and have less power to detect significant effects.

Table 3 provides odds ratios, derived from the logistic regression models, that indicate the size of the effects of some of these characteristics. All of the models controlled for exposure, measured as number of hours at risk in the case of the two month-specific indicators and as number of years at risk in the case of the

"ever stuck" measure. The numbers in the first two rows of Table 3 indicate that the frequency with which nurses handled blood was positively related to whether they reported injuries. Five of the six odds ratios were greater than 1.5, implying that nurses who often or sometimes handled blood had odds of being injured that were more than 50% greater than those of nurses who rarely or never handled blood. These ratios were statistically significant only with respect to the ever-injured measure, however. Nurses who sometimes handled blood were 1.6 times more

**TABLE 3—Odds Ratios (95% Confidence Intervals) Indicating the Effects of Various Factors on the Odds of Prospectively and Retrospectively Reporting Needlesticks among Nurses in 20 Hospitals in 11 Cities, 1990 through 1991**

Factor	Categories Contrasted	Dependent Variable		
		Prospectively Reported Needlesticks	Retrospectively Reported Needlesticks (Past 30 Days)	Retrospectively Reported Needlesticks (Ever)
Frequency of handling blood	Sometimes vs rarely or never	2.128 (0.588, 7.706)	1.589 (0.563, 4.489)	1.570** (1.001, 2.461)
	Often vs rarely or never	2.079 (0.600, 7.196)	0.861 (0.296, 2.500)	2.350** (1.531, 3.606)
Frequency of recapping needles	Sometimes or often vs never	1.397 (0.685, 2.849)	2.167** (1.041, 4.511)	1.773** (1.313, 2.395)
Frequency of precautions to avoid contact with blood/body fluid	Always vs not always	1.382 (0.556, 3.433)	0.876 (0.382, 2.010)	0.466** (0.328, 0.662)
Hospital type	Magnet vs nonmagnet	0.365* (0.126, 1.058)	0.177** (0.042, 0.746)	...
Unit type	AIDS-dedicated vs scattered-bed	0.633 (0.252, 1.589)	0.920 (0.399, 2.118)	...

*Note.* Odds ratios were derived from logistic regression models that controlled for time exposed to risk (i.e., number of hours worked in the month of the prospective study and the 30-day period referenced by the retrospective question, and number of years worked as a nurse in the case of the retrospective "ever stuck" question). All regressions, except for those in which unit type was the factor considered, involved sample sizes of between 698 and 732. The effect of unit type was assessed only for nurses in nonmagnet hospitals ( $n = 527$ ). Since the hospitals and units nurses worked in at the time of the injuries that "ever" occurred to them may have differed from the hospitals and units they were on at the time they filled out questionnaires, we did not attempt to use current hospital or unit type to predict whether nurses had ever been stuck.

\*Significant at the .10 level.

\*\*Significant at the .05 level.

likely than those who rarely or never handled blood to have ever been injured, and those who often handled blood were more than twice as likely as those who rarely or never did to have ever been injured.

Recapping needles and taking precautions to avoid contact with patients' blood or body fluids were both related to whether nurses had ever sustained needlestick injuries, and recapping needles appeared to be similarly related to the prospective- and retrospective-report monthly injury rates. Nurses who sometimes or often recapped needles were 1.4 times more likely than those who never did to report an injury during the prospective part of the study; 2.2 times more likely to retrospectively report an injury in the previous month; and 1.8 times more likely to report having ever been stuck. Nurses who always took precautions were not significantly less likely than others to report injuries in the short term, but they were significantly less likely, and less than half as likely, as nurses who did not always take precautions to report having ever been stuck.

Finally, with respect to whether organizational factors were related to the likelihood of being injured, working in a magnet hospital significantly reduced the odds of reporting both an injury prospec-

tively and one retrospectively in the previous month, whereas working on a dedicated AIDS unit was not associated with injuries. Nurses in magnet hospitals were less likely than nurses in nonmagnet hospitals to report having been injured during a 1-month period, by a factor of 0.37 in the case of the prospective reports and by a factor of 0.18 in the case of the retrospective reports. Nurses working on dedicated AIDS units had slightly lower odds than nurses on scattered-bed units of reporting injuries during a 1-month period, but neither of the odds ratios describing unit-type differences in prospective or retrospective reports was significant.

## Discussion

Hospital nurses' risk of injuries associated with occupational exposure to blood is greater than institutional data would suggest. The prospective- and retrospective-report data used in this study yielded similar estimates, indicating that nurses sustain on average 0.7 or 0.8 injuries per year, or between 3 and 4 injuries every 5 years. The well-known deficiencies of self-reported retrospective data (telescoping, memory decay, etc.) either do not obtain in the reporting of

events as significant as needlesticks or are offsetting.

Injuries do not occur at random, nor were the substantial rates of needlestick injuries we found caused by a few nurses who were injured repeatedly. Certain nursing practices are related to the likelihood of being injured, and recapping needles appears to be most important among them. That recapping persists in spite of the well-documented hazards and Centers for Disease Control and Prevention recommendations against the practice<sup>19</sup> suggests that providing nurses with safer devices<sup>7,20</sup> is warranted despite the higher costs of such devices and the seeming opposition of a sizable percentage of hospital managers to paying for them.<sup>21</sup>

We found that organizational factors were associated with rates of needlestick injuries. Temporary nurse staffing was related to higher injury rates and organizational models promoting decentralization and professional autonomy were associated with lower injury rates. The Institute of Medicine's recent report on nurse staffing and safety calls for greater managerial attention to promising strategies for creating safer work environments for hospital nurses.<sup>22</sup> Our findings point strongly toward the need for such attention and indicate that the recent downsiz-

ing and "deprofessionalizing" of the hospital workforce<sup>23</sup> is not without potential adverse consequences. □

## Acknowledgments

This work was supported by grant R01 NR02280 from the National Institute for Nursing Research, National Institutes of Health, and the Centers for Disease Control and Prevention.

We are grateful to David M. Bell, MD, Hospital Infections Program, National Center for Infectious Diseases, Centers for Disease Control and Prevention, for many helpful suggestions.

## References

1. Goldsmith MF. Even "in perspective," HIV specter haunts health care workers most. *JAMA*. 1990;263:2413,2417,2420.
2. Colombotos J, Messeri P, McConnell MB, et al. *Physicians, Nurses, and AIDS: Findings From a National Study*. Rockville, Md: Agency for Health Care Policy and Research; 1995. (Available from National Technical Information Service [NTIS], Springfield, Va; NTIS no. PB95-129185.)
3. Dworkin J, Albrecht G, Cooksey J. Concerns about AIDS among hospital physicians, nurses and social workers. *Soc Sci Med*. 1991;33:239-248.
4. Gershon RR, Curbow B, Kelen G, Celantano D, Lears K, Vlahou D. Correlates of attitudes concerning human immunodeficiency virus and acquired immunodeficiency syndrome among hospital workers. *Am J Infect Control*. 1994;22:293-299.
5. Rogers DE, Ginzberg E. *Public and Professional Attitudes toward AIDS Patients*. Boulder, Colo: Westview Press; 1989.
6. Centers for Disease Control and Prevention. Table 16. Health care workers with documented and possible occupationally acquired AIDS/HIV infection, by occupation, reported through December 1995, United States. *HIV/AIDS Surveill*. 1995; 7(2):21.
7. Jagger J, Hunt EH, Brand-Elnaggar J, Pearson RD. Rates of needle-stick injury caused by various devices in a university hospital. *N Engl J Med*. 1988;319:284-288.
8. Davis GL. Hepatitis C virus infection among health-care workers. *JAMA*. 1996; 275:1474.
9. Centers for Disease Control and Prevention. Disease burden from viral hepatitis A, B, and C in the United States. Unpublished data from Ian Williams, Hepatitis Branch, February 1996.
10. Marcus R, the CDC Cooperative Needlestick Surveillance Group. Surveillance of health care workers exposed to blood from patients infected with the human immunodeficiency virus. *N Engl J Med*. 1988;319: 1118-1123.
11. Chamberland ME, Ciesielski CA, Howard RJ, Fry DE, Bell DM. Occupational risk of infection with human immunodeficiency virus. *Surg Clin North Am*. 1995;75:1057-1070.
12. Bell DM, Shapiro CN, Ciesielski CA, Chamberland ME. Preventing bloodborne pathogen transmission from health-care workers to patients. *Surg Clin North Am*. 1995;75:1192.
13. Centers for Disease Control and Prevention. Case-control study of HIV seroconversion in health-care workers after percutaneous exposure to HIV infected blood—France, United Kingdom, and United States, January 1988–August 1994. *MMWR*. 1995;44:929-933.
14. Justice AC, Aiken LH, Smith HL, Turner BJ. The role of functional status in predicting inpatient mortality with AIDS: a comparison with current predictors. *J Clin Epidemiol*. 1996;49:193-201.
15. Aiken LH, Lake ET, Sochalski J, Sloane DM. Design of an outcomes study of the organization of hospital AIDS care. *Res Soc Health Care*. In press.
16. Kramer M, Schmalenberg C. Magnet hospitals: institutions of excellence, parts I and II. *J Nurs Adm*. 1988;18:11-24.
17. Aiken LH, Smith HL, Lake ET. Lower Medicare mortality among a set of hospitals known for good nursing care. *Med Care*. 1994;32:771-785.
18. Rothman KJ. *Modern Epidemiology*. Boston, Mass: Little, Brown & Co; 1986.
19. Centers for Disease Control and Prevention. Recommendations for prevention of HIV transmission in health-care settings. *MMWR*. 1987;36(suppl 2S):1S-18S.
20. Jagger J. A new opportunity to make the health care workplace safer. *Adv Exposure Prev*. 1994;1:1-2.
21. Gravell EL. Survey wants to know: safety first? *Materials Manage Healthcare*. 1995; 4:48-50.
22. Institute of Medicine. *Nursing Staff in Hospitals and Nursing Homes: Is It Adequate?* Washington, DC: National Academy Press; 1996.
23. Lumsdon K. Faded glory: will nursing ever be the same? *Hosp Hosp Networks*. December 5, 1995:31-35.